

Understanding and Assessing Climate Change: Preparing for Nebraska's Future

2024 Climate Change Impact Assessment Report Chapter 9 - Human Health



Chapter 9

Human Health

Jesse E. Bell and Kristina W. Kintziger

*Corresponding authors: jesse.bell@unmc.edu, kkintziger@unmc.edu

Key messages

1. Climate change is associated with adverse health outcomes in Nebraska, including heat-related morbidity and mortality during heat waves, physical and mental health impacts during drought and flood events, and increased risk of certain infectious diseases like West Nile virus due to changing temperature and precipitation patterns.
2. Some Nebraskans are more impacted by the health impacts associated with climate change than others.
3. Adaptation and mitigation efforts addressing the health impacts of climate change can protect Nebraskans.

Complex relationships between climate and human health

Climate change impacts individual-level physical and mental health and community-level health. The exposure pathways through which climate affects health are complex and varied. Climate drivers (i.e., the climatological and meteorological conditions that impact the environment and ecosystems) include increased temperatures, precipitation extremes, and other extreme weather events. These drivers influence or initiate the exposure pathways, or main routes, through which climate affects health. Examples of such pathways are extreme heat, poor air or water quality, changes in the distribution of infectious diseases (e.g., the expanded geographic range of ticks that carry Lyme disease, changes in the seasonality of *Salmonella* species), climate and extreme weather-related disasters, and population displacement (USGCRP, 2016; Liu et al., 2021). These exposure pathways can impact human health directly (the climate or weather factor affects human health via some mechanism of bodily harm without a mediating or intervening factor) or indirectly (the climate or weather factor initiates a chain of events that leads to harm). Direct impacts may include heat-related illness, injury, or death. Indirect impacts may include food, water, and vector-borne diseases; hunger and malnutrition; and mental health impacts.

These impacts on human and community health may be further exacerbated when climate- and weather-related extreme events occur simultaneously or in proximity to each other (i.e., compounding hazards) or when one such extreme event leads to a series of subsequent events (i.e., cascading hazards) (Hayden et al., 2023). An example of compounding climate-related hazards is a heat wave and drought occurring together, leading to higher rates of heat-related illnesses and hospitalizations. Some related examples of cascading hazards might be when this initial heat wave–drought combination leads to the following:

- » Widespread wildfires and reduced air quality, increasing emergency department visits and hospitalizations for asthma and other respiratory conditions.
- » Water shortages that impact the agricultural industry (e.g., through crop or livestock losses), leading to local and regional food insecurity or increased mental health impacts among farmers.
- » The failure of overloaded energy grids, increasing the risk of carbon monoxide poisoning from generators, heat-related illness hospitalizations and deaths from loss of cooling systems, and disruption of other systems (e.g., water treatment plants, transportation, hospitals).

Additional factors that intensify the impacts of climate on health are existing social inequities, including systemic racism and discrimination (Berberian et al., 2022). We know that climate- and extreme-weather-related hazards disproportionately impact certain communities, those with a greater vulnerability or those that have historically been marginalized. These include people of color, Indigenous communities, women, children, aging populations, people with disabilities and chronic health conditions, and sexual and gender minorities (Hayden et al., 2023). Some communities are already facing environmental threats to their health and well-being due to the historical practice of redlining. These communities received less investment and are now under resourced relative to healthcare, infrastructure, education, economy, housing, and other basic needs (Egede et al., 2023). The combined impacts of climate change and these existing environmental hazards greatly exacerbate health inequities in these communities. Environmental justice challenges are described in further detail in Chapter 12, “Climate Justice and Equity.”

Given the multiple, complex, and interacting climate hazards and exposure pathways, it can be challenging to fully understand the extent to and the mechanisms by which climate impacts human health. However, the evidence is clear that every American is impacted by climate change (USGCRP, 2023); climate and extreme weather affect mental, physical, and community health (Hayden et al., 2023); and continued efforts to understand these impacts and use this knowledge to drive adaptation and mitigation actions are needed to protect human health.

Climate and health in Nebraska

Climate and extreme weather also affect Nebraskans' health. As described in Chapters 2 through 4, Nebraska faces impacts from climate extremes, including severe drought, flooding, increasing temperatures, and wildfires. We describe these hazards' exposure pathways and health impacts based on available scientific evidence, specific to Nebraska and the Midwest, where possible.

Increasing temperatures and heat waves

Global warming is leading to increasing daytime and nighttime temperatures, higher humidity, and longer and more frequent heat waves. Extreme heat is associated with a variety of health outcomes, including heat-related illnesses (i.e., heat exhaustion and heat stroke), cardiovascular diseases and stroke, respiratory disease, renal disease, dehydration, diabetes, mental health conditions and behavioral disorders, and death. These risks are increased for certain people who are more vulnerable to the effects of heat (e.g., very young or very old, people with certain chronic conditions or taking certain medications, those who rely on the environment for their livelihood, people with lower education or income, and people who are incarcerated) and people living in urban areas.

Heat vulnerability mapping has highlighted Omaha, Nebraska's largest city, as having distinct geographical and socioeconomic characteristics compared to the rest of the state (Figure 9.1). Rural and urban areas of Nebraska have distinct differences in what makes each area vulnerable to extreme heat. For example, heat vulnerability in Omaha is largely driven by disability, poverty, and urbanization. In many other parts of the state, heat vulnerability is determined by education, race other than White, and land class, including grasslands and pasture (Fard et al., 2021). Historically, Omaha has been shaped by redlining practices that segregated racial and ethnic minority communities, creating persistent disparities in residential distribution. This segregation has been linked to various health disparities and environmental challenges (Puvvula et al., 2023).

Urban heat islands experience elevated temperatures due to their built environments, which absorb and re-radiate heat more than natural landscapes. Roads, parking lots, buildings, and other infrastructure contribute to these higher temperatures (NIHHIS, n.d.). The National Oceanic and Atmospheric Administration (NOAA) Urban Heat Island Mapping Project provided data on Omaha's hottest neighborhoods. On August 6, 2022, 68 volunteers collected 43,714 temperature measurements across eight routes, revealing a maximum temperature of 102.9°F with a daily temperature variation of 9.4°F (Fard, 2024). The study identified three key findings for the Omaha area. First, residential areas with significant tree cover generally have cooler temperatures and retain less heat throughout the day. Second, regions with high-density industrial land use tend to retain more heat. Third, large expanses of asphalt in commercial areas contribute to higher temperatures due to increased heat retention. These insights underscore the impact of urban design and land use on local heat vulnerabilities.

From 2018 to 2022, 2,406 emergency department visits and 193 hospitalizations were reported from heat-related illnesses in Nebraska. Emergency department visits were the lowest in 2020 ($n = 343$) and highest in 2022 ($n = 611$). The age-adjusted rates of emergency department visits during this period ranged from 16.9 to 30.6 per 100,000 population. During this same period, average summer (May through September) temperatures in Nebraska ranged from 67.1°F (19.5°C) to 69.8°F (21°C). The average temperature in 2022 was the highest during the observation period (69.8°F (21°C), or a 2.5°F (1.39°C) anomaly from the base period), coinciding with the highest reported emergency department visits. The average temperature in 2020 was 68.5°F (20.3°C), or a 1.2°F (0.67°C) anomaly from the base period (1901 to 2000), not the lowest average temperature of the period (NOAA NCEI, 2024a). Lower emergency department visit rates during 2020 may be somewhat attributable to the COVID-19 pandemic. Emergency department visits for heat-related illnesses were most common in males, non-Hispanic White individuals, and those aged 20 to 29 and 30 to 39 years; they were also more likely to occur in July. Hospitalizations were the lowest in 2021 ($n = 34$) and highest in 2022 ($n = 44$), with age-adjusted rates ranging from 1.6 to 1.9 per

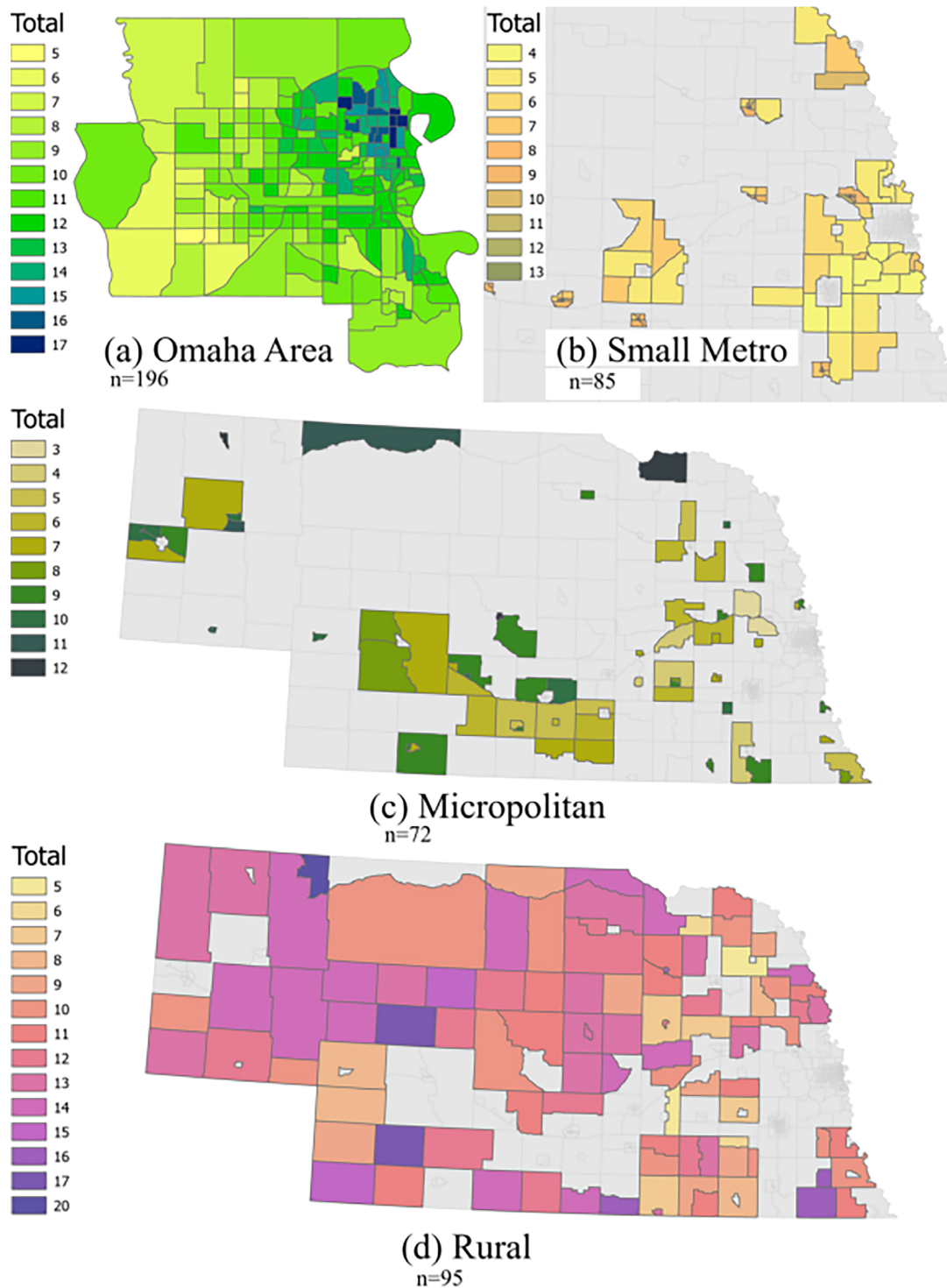


Figure 9.1. Maps of heat vulnerability level values in each of the four urban classes in Nebraska: (a) Omaha, the most populated Medium Metropolitan area; (b) part of Small Metro area (eastern Nebraska as in Fig. 1[a]); (c) micropolitan areas; (d) rural areas. (Source: Fard et al., 2021)

100,000 population. Hospitalizations for heat-related illnesses were also common in males and non-Hispanic White individuals and were more likely to occur in July. However, hospitalizations were more likely to occur in individuals over the age of 60 (CDC, n.d.).

Precipitation extremes: drought

Drought is one of the costliest climate-related disasters in the United States. Nebraska alone has suffered losses exceeding \$10 billion since 1980, making it the state's most expensive natural disaster (NOAA NCEI, 2024c). The impacts of a single drought event are often compounded by previous droughts and other weather-related hazards, creating complex interactions. These include reduced water quality, air quality issues, more intense heat waves, wildfires, dust storms, and decreased water availability (Bell et al., 2023). Research indicates that drought can increase arsenic levels in private wells, which are linked to cancer, adverse birth outcomes, and developmental issues (Lombard et al., 2021). Additionally, drought can cause pulmonary inflammation from dry weather and dust, increase vector-borne diseases due to standing water from reduced water levels, and heighten gastrointestinal and infectious diseases due to decreased sanitation. Mental health also suffers due to various hardships caused by drought (Hayden et al., 2023).

Studies show that severe droughts disproportionately affect rural communities and individuals over the age of 65, increasing the risk of mortality from all causes, cardiovascular issues, and respiratory conditions. For example, research in Nebraska has found that all-cause mortality increases for White populations aged 25 to 34 and 45 to 64 during severe droughts (Abadi et al., 2022). A broader study of the northern plains, including Nebraska, found that severe droughts also increase mortality among those over 65, White subgroups, and females. Additionally, areas with fewer drought conditions have exhibited higher mortality risks, highlighting the complex relationship between drought and health impacts (Gwon et al., 2024).

Further research has shown that severe droughts lead to a significant increase in respiratory-related mortality, affecting both White and Black subgroups, with females experiencing a greater impact than males. Rural populations are particularly vulnerable,

experiencing higher increases in respiratory-related mortality compared to urban areas (Gwon et al., 2023). Another study focusing on Nebraska and the surrounding region found that severe droughts also increase cardiovascular-related mortality, with higher risks observed among females, White individuals, and those over 65 (Gwon et al., 2024).

Drought has also been shown to impact mental health. Farmers' occupational psychosocial stress—job strain—in the Midwest was significantly higher with drought conditions during the growing season compared to the non-growing season. Specifically, psychological job demands increased by 109% when drought occurred during the growing season (Berman et al., 2021). In the U.S., firearm and non-firearm suicides were associated with all phases of drought. In severe drought periods, the risk of suicide was increased overall and in older adults, women, and individuals living in rural areas (Abadi et al., 2024).

Precipitation extremes: flood

In 2019, Nebraska and other midwestern states experienced an inland flooding event that caused an estimated \$13.4 billion in economic losses. The event inundated millions of acres of agricultural lands, cities, and towns and caused widespread damage to infrastructure across eight states (NOAA NCEI, 2024c). In Nebraska, 104 cities, 81 counties, and 5 Tribal nations (Figure 9.2) received state or federal disaster declarations because of this event (Bell et al., 2020), with an estimated \$2.6 billion in economic losses, including damage to homes, businesses, infrastructure, farmland, and livestock (Reed, 2022). The Federal Emergency Management Agency (FEMA) processed and approved over 3,000 individual assistance applications and more than \$27 million in Individual and Household Program funds (Figure 9.2). The flooding caused severe damage to infrastructure, including bridges, dams, levees, and roads. The 2019 floods exacerbated the hardships faced by already vulnerable communities, with many Tribes and Indigenous peoples enduring additional challenges that compounded historical trauma, including delayed responses from outside emergency services and inadequate resources for evacuations (Bell et al., 2020).

FEMA-4420-DR, Nebraska Disaster Declaration as of 10/10/2019



FEMA

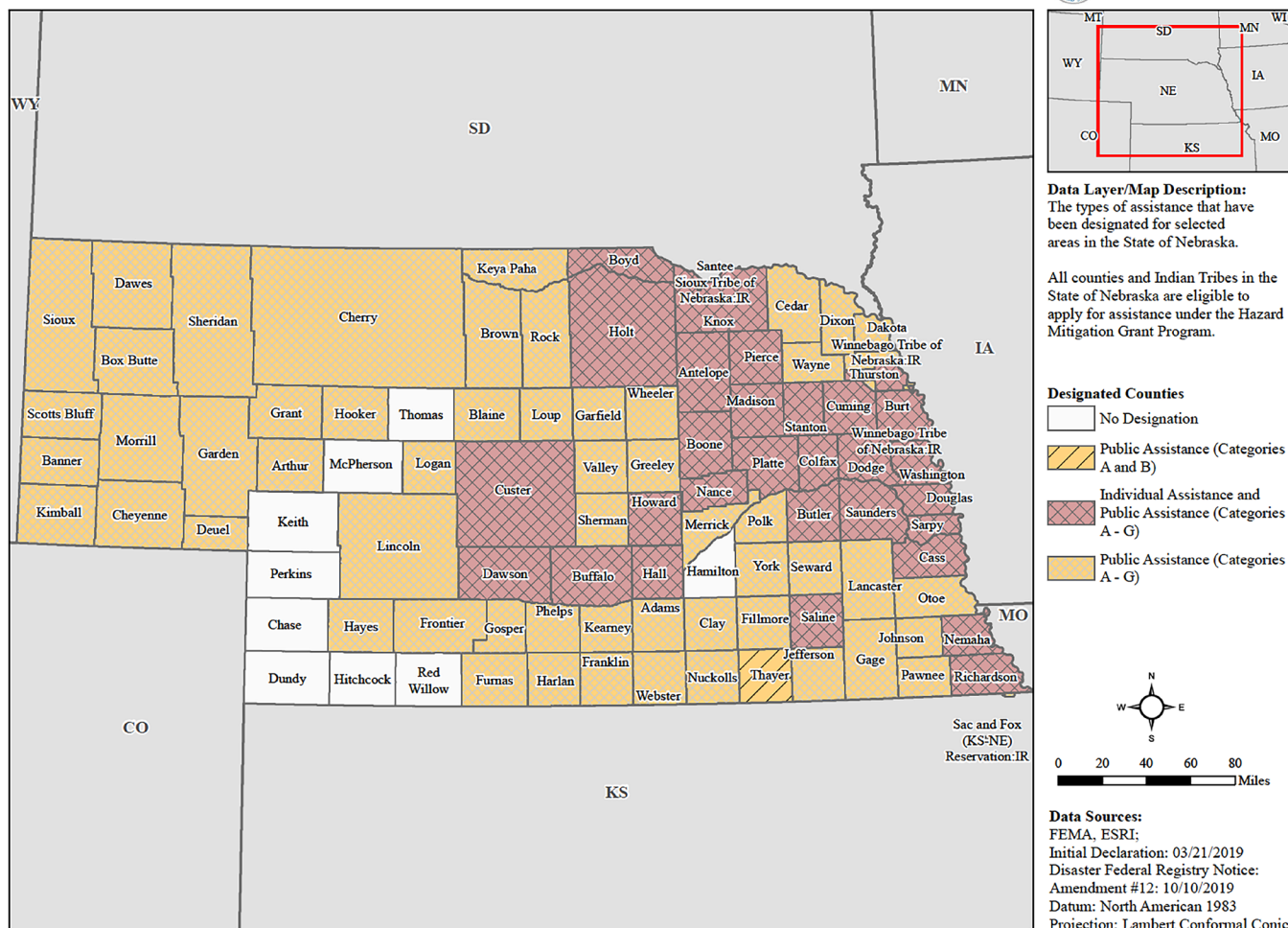


Figure 9.2. Map of the types of assistance designated for selected counties in Nebraska related to the Federal Emergency Management Agency (FEMA) disaster declaration for 2019 Missouri River flooding (FEMA Disaster 4420). (Source: FEMA, n.d.)

Four deaths were recorded (Reed, 2022) due to drowning, but the hidden health impacts were extensive and went beyond immediate flood-related injuries. In the aftermath, individuals in affected areas were exposed to additional hazards, such as chemicals, electrical shocks, and debris. Contamination of water sources, including wells, increased gastrointestinal illness risks, particularly for children. Stranded residents depended on emergency services, volunteer organizations, and community support for essential supplies like clean water (Bell et al., 2020). Infrastructure was also compromised after the flood, including mold development in homes. Mold growth is a common occurrence after major flooding. Exposure to mold affects the skin, eyes, and respiratory system and may lead to infections and allergic reactions (Metts, 2008).

The disaster highlighted significant challenges in response and recovery efforts for resource-limited communities. The lack of equipment and limited transportation options further complicated evacuation and relief efforts, leaving many residents in dire conditions. This situation calls for reevaluating disaster preparedness and response strategies to better support vulnerable populations in future emergencies.

The 2019 flood disaster mirrored previous flooding events in terms of health impacts and disruptions to the healthcare system, disproportionately affecting vulnerable populations, particularly Tribal and Indigenous communities. This situation underscores the urgent need for policy interventions to minimize health risks, improve health equity, and enhance community resilience as the frequency of such weather

events rises. The disaster displaced hundreds of people, inundated millions of acres of agricultural land, killed thousands of livestock, and hindered crop planting. FEMA disaster declarations were issued throughout the region, allowing affected individuals to seek financial and housing assistance, although remaining in their homes still left them at risk of future flooding.

Air pollution

Nebraska's air quality will likely worsen due to climate change as wildfires and dust storms become more common. These issues can compound underlying inequities. Marginalized communities, particularly those affected by social vulnerabilities such as race, ethnicity, and poverty, face higher exposure to harmful pollutants, including carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), ozone (O₃), and particulate matter (PM_{2.5} and PM₁₀) (West et al., 2023). Research has shown these disparities through community-scale and personal monitoring studies (Hajat et al., 2015).

In Douglas County, Nebraska, one study found strong links between elevated criteria pollutants (like CO, PM_{2.5}, NO₂, and SO₂) and factors such as race (particularly non-Hispanic Black and Hispanic/Latino populations), financial stability, and literacy. Additionally, neighborhoods with higher proportions of Non-Hispanic Black children, uninsured children, and households lacking vehicle access experienced more pediatric asthma emergency visits (Puvvula et al., 2023). Another study highlighted the impact of specific pollutants, such as PM_{2.5}, sycamore and grass pollen, and mold (including *Helminthosporium*, *Peronospora*, and *Erysiphe*), in exacerbating pediatric asthma in Douglas County (Puvvula et al., 2022). These findings underscore the complex relationship between air quality and health outcomes in vulnerable communities.

Vector-borne diseases

Climate change can broaden the range and increase the activity of disease vectors like mosquitoes and ticks by creating more favorable conditions for their reproduction and survival. Warmer temperatures and altered precipitation patterns can also extend the transmission season of vector-borne diseases, leading to increased infection rates in previously unaffected areas. In Nebraska, four mosquito-borne viruses pose

a significant risk: West Nile virus, St. Louis encephalitis, western equine encephalitis, and Jamestown Canyon virus. Additionally, ticks in Nebraska can transmit serious diseases such as Lyme disease, ehrlichiosis, Rocky Mountain spotted fever, and tularemia.

A study on West Nile virus in Nebraska found that dry years following wet ones, especially with warm temperatures, increased the likelihood of infection, with drought contributing to approximately 26% of cases from 2002 to 2018 (Smith et al., 2020). Recent surveys have also identified populations of *Ixodes scapularis* ticks, confirming the presence of *Borrelia burgdorferi*. There is also evidence of local Lyme disease transmission in the state. Lone Star ticks (*Amblyomma americanum*) are present in Nebraska, where they pose health risks due to their role in transmitting diseases like ehrlichiosis and tularemia. Although these ticks are more commonly found in the southeastern and south central United States, their range is expanding northward, leading to their presence in Nebraska and other northern regions. Additionally, Lone Star ticks are associated with Alpha-gal syndrome (AGS), an allergy to certain types of meat caused by tick bites (NDHHS, n.d.).

Addressing health threats in Nebraska

While these and other climate-related threats have and will continue to impact Nebraskans' health, much is being done to address these issues. Since 2022, Nebraska has been one of 33 recipients of a Centers for Disease Control and Prevention (CDC) National Environmental Public Health Tracking cooperative agreement that aims to collect, integrate, analyze, and disseminate data from various sources to monitor the burden from environmentally related health outcomes in the U.S. (CDC, n.d.) The Nebraska Tracking Program is a joint effort between the Nebraska Department of Health and Human Services (DHHS) and the University of Nebraska Medical Center (UNMC) and is using this funding to develop a Nebraska Tracking Data Portal and address environmental issues of concern to our state. Many indicators tracked by the national and state tracking programs include

climate-related risks and health outcomes. On the environmental side, this includes information about extreme heat, drought, air quality, precipitation, and flooding, among others. On the health side, tracking programs monitor respiratory conditions like asthma and chronic obstructive pulmonary disease, heat-related illnesses, and cardiovascular conditions such as heart attack and stroke, among others.

The state and several metropolitan areas, including Lincoln, Omaha, and the larger Omaha–Council Bluffs Metropolitan Statistical Area, have been working to develop and build climate action and resilience plans to improve our sustainability for the future (City of Lincoln, 2021; City of Omaha, 2024). These plans inventory greenhouse gas emissions, identify focus areas for reduced emissions, and set target limits for emissions in the future. Reductions in greenhouse gas emissions will improve air quality. Many greenhouse gases are also considered air pollutants and strategies to reduce their emissions often overlap with actions to decrease other harmful air pollutants, such as particulate matter and sulfur dioxide (West et al., 2023). Therefore, mitigating climate change through greenhouse gas reduction can positively impact air quality and public health. Climate action and resilience plans also include sustainable economic development. Initiatives like this will add jobs in specific sectors and improve the local economy while focusing on

the built environment and increasing green spaces and tree canopy. Many of these plans also consider healthcare systems and other impacts on human health. These efforts will have long-term implications for individuals' physical and mental health and improve overall quality of life and community resilience.

Gaps and needs

- » Improved monitoring and surveillance systems to track the impacts of climate change on health in real-time.
- » Research into the complex interactions between extreme heat, air pollution, and drought on physical and mental health impacts.
- » Epidemiologic studies examining the short- and long-term effects of extreme weather events on health, particularly indirect health impacts, including heat waves, floods, droughts, wildfires, and severe storms.
- » Development and evaluation of community-level adaptation strategies to mitigate the health risks associated with climate change.
- » Assessments related to local healthcare systems resiliency and capacity to respond to climate-related events and infrastructure adaptations to withstand these events.